CLAIMS

1. Combined laser-based apparatus for determining both altitude and ground velocity of an aircraft, said apparatus comprising:

a laser source for emitting pulsed laser beams substantially at a predetermined wavelength over a first optical path;

a plurality of first optical elements for directing said laser beams from said first optical path to a second optical path which exits said first optical elements;

a plurality of second optical elements configured to form a telescope with a predetermined field of view, said second optical path and telescope field of view being fixedly co-aligned;

an optical scanner disposed in said second optical path for directing said second optical path and telescope field of view to desired ground positions while maintaining the co-alignment thereof;

said telescope for receiving from said desired ground positions Doppler wavelength shifted reflections of said pulsed laser beams within the field of view thereof and directing said received ground reflections substantially over a third optical path;

an optical filter element disposed in said third optical path for separating the ground reflections of said third optical path into first and second portions that are dependent on the Doppler wavelength shift of said ground reflections; and

processing means for determining altitude and ground velocity of said aircraft based on said first and second portions.

2. The apparatus of claim 1 wherein the processing means includes:

a first light detector for receiving and converting said first portion of ground reflections into first electrical signals representative thereof;

a second light detector for receiving and converting said second portion of ground reflections into second electrical signals representative thereof; and

a processor for determining the ground speed of the aircraft at each ground position based on a function of the first and second electrical signals.

3. The apparatus of claim 2 wherein the processing means includes a means for determining a laser beam ground scan vector of the scanner for each ground position; and wherein the processor is operative to associate the ground speed with the corresponding ground scan vector for each ground position.

4. The apparatus of claim 3 wherein the processor is operative to determine ground velocity using the ground speeds and corresponding ground scan vectors of at least three ground positions.

5. The apparatus of claim 4 wherein the processor is operative to determine ground velocity by a triangulation of the ground speeds and corresponding ground scan vectors of the at least three ground positions.

6. The apparatus of claim 2 wherein the processor is operative to determine the ground speed of the aircraft at a ground position based of a ratio of a difference over a sum of the first and second electrical signals corresponding to the ground position.

7. The apparatus of claim 1 wherein the optical filter element is operative to transmit the first portion of the ground reflections of said third optical path therethrough and to reflect the second portion of the ground reflections of said third optical path to a fourth optical path, said transmission and reflection of the first and second portions by the optical filter element being dependent on the Doppler wavelength shift of said ground reflections.

8. The apparatus of claim 7 wherein the optical filter element has a sharp cut off transmission response with respect to wavelength such that a small Doppler shift in wavelength away from the laser emission wavelength will produce a detectable change in transmission characteristics of the optical filter element.

9. The apparatus of claim 8 wherein the optical filter element is tuned to receive the laser emission wavelength along a cut off edge of the transmission response.

10. The apparatus of claim 9 wherein the optical filter element is tuned to receive the laser emission wavelength at approximately midway of the cut off edge of the transmission response.

11. The apparatus of claim 7 comprises a dichroic beam splitter.

12. Laser-based apparatus for generating signals for use in determining both altitude and ground velocity of an aircraft, said apparatus comprising:

a laser source for emitting pulsed laser beams substantially at a predetermined wavelength over a first optical path;

a plurality of first optical elements for directing said laser beams from said first optical path to a second optical path which exits said first optical elements;

a plurality of second optical elements configured to form a telescope with a predetermined field of view, said second optical path and telescope field of view being fixedly co-aligned;

said telescope for receiving Doppler wavelength shifted reflections of said pulsed laser beams within the field of view thereof and directing said received reflections substantially over a third optical path;

an optical filter element disposed in said third optical path for separating the reflections of said third optical path into first and second portions that are dependent on the Doppler wavelength shift of said reflections; and

light detection means for receiving said first and second portions and generating first and second signals representative of said first and second portions, respectively.

13. The laser-based apparatus of claim 12 wherein the laser source is autonomously operative to periodically generate laser pulses; and wherein the light detection means is operative to generate the first and second signals corresponding to each laser beam reflection.

14. The laser-based apparatus of claim 13 including a means for generating a pulse signal representative of a start of each laser pulse period.

15. The apparatus of claim 12 wherein the optical filter element is operative to transmit the first portion of the reflections of said third optical path therethrough and to reflect the second portion of the reflections of said third optical path to a fourth optical path, said transmission and reflection of the first and second portions by the optical filter element being dependent on the Doppler wavelength shift of said reflections.

16. The apparatus of claim 15 wherein the optical filter element has a sharp cut off transmission response with respect to wavelength such that a small Doppler shift in wavelength away from the laser emission wavelength will produce a detectable change in transmission characteristics of the optical filter element.

17. The apparatus of claim 16 wherein the optical filter element is tuned to receive the laser emission wavelength along a cut off edge of the transmission response.

18. A distributed laser-based system for use on-board an aircraft for determining both altitude and ground velocity of said aircraft, said system comprising:

at least three laser-based measurement apparatus for disposition at different locations on said aircraft, each said apparatus comprising:

a laser source for emitting pulsed laser beams substantially at a predetermined wavelength over a first optical path;

a plurality of first optical elements for directing said laser beams from said first optical path to a second optical path which exits said first optical elements;

a plurality of second optical elements configured to form a telescope with a predetermined field of view, said second optical path and telescope field of view being fixedly co-aligned;

said telescope for receiving Doppler wavelength shifted reflections of said pulsed laser beams within the field of view thereof and directing said received reflections substantially over a third optical path;

an optical filter element disposed in said third optical path for separating the reflections of said third optical path into first and second portions that are dependent on the Doppler wavelength shift of said reflections; and

light detection means for receiving said first and second portions and generating first and second signals representative of said first and second portions, respectively;

each said laser-based apparatus configurable to direct its co-aligned second optical path and telescope field of view from said aircraft to a different ground position from the other laser-based apparatus; and

a processing unit for receiving and processing said first and second signals from said at least three laser-based apparatus to determine both said altitude and ground velocity of said aircraft.

19. The system of claim 18 wherein the processing unit is operative to determine a ground speed of the aircraft for each laser-based apparatus based on a function of the corresponding first and second signals generated thereby.

20. The system of claim 19 wherein the processing unit is operative to associate the ground speed with the corresponding laser beam directional configuration of the at least three laser-based apparatus, and operative to determine ground velocity using the ground speeds and corresponding laser beam directions of the at least three laser-based apparatus.

21. The system of claim 20 wherein the processing unit is operative to determine ground velocity of the aircraft by a triangulation of the ground speeds and corresponding laser beam directions of the at least three laser-based apparatus.

22. The system of claim 18 wherein the processing unit is operative to determine a ground speed of the aircraft for each of the at least three laser-based apparatus based on a ratio of a difference over a sum of the first and second signals corresponding thereto.

23. The system of claim 18 wherein the laser source of each of the at least three laser-based apparatus is autonomously operative to periodically generate laser pulses; and wherein the light detection means of each of the at least three laser-based apparatus is operative to generate the first and second signals corresponding to each received laser beam reflection.

24. The system of claim 23 wherein each laser-based apparatus includes means for generating a pulse signal representative of a start of each laser pulse period thereof.

25. The system of claim 24 wherein the processing unit is operative to determine altitude of the aircraft based on the pulse signal and at least one of the first and second signals of at least one of the at least three laser-based apparatus.